

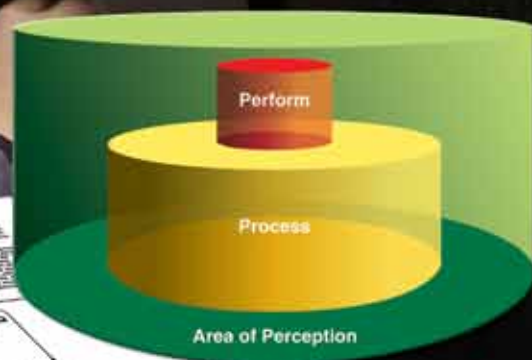
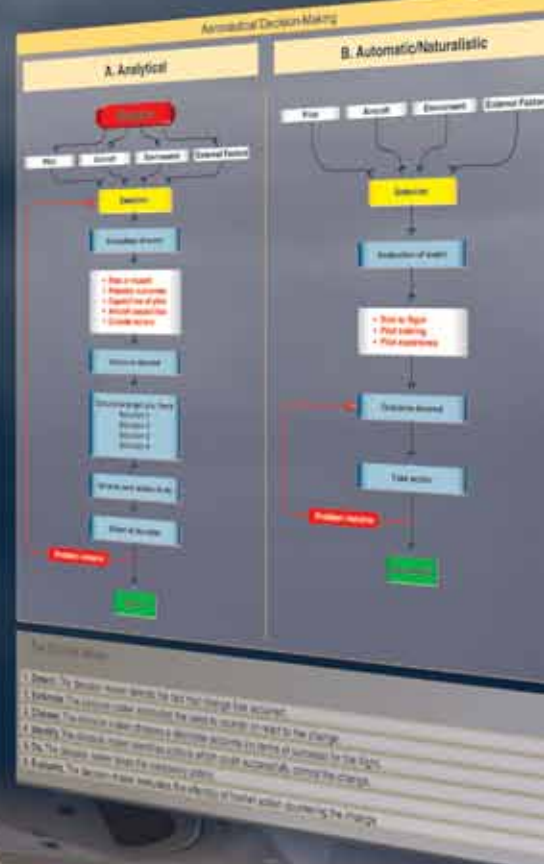
## Chapter 5

# Aeronautical Decision-Making: A Basic Staple

### Introduction

Aeronautical decision-making (ADM) is a cornerstone in managing risk. ADM provides a structured framework utilizing known processes and applying recognized pathways, which individually and collectively have a positive effect on exposure to hazards. This is not achieved by reducing the hazard itself, but by helping the pilot recognize hazards that need attention.

ADM is a systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances. It is what a pilot intends to do based on the latest information he or she has.



The importance of learning and understanding effective ADM skills cannot be overemphasized. While progress is continually being made in the advancement of pilot training methods, aircraft equipment and systems, and services for pilots, accidents still occur. Despite all the changes in technology to improve flight safety, one factor remains the same: the human factor, which leads to errors. It is estimated that approximately 80 percent of all aviation accidents are related to human factors, and the vast majority of these accidents occur during landing (24.1 percent) and takeoff (23.4 percent).

ADM helps reduce risk. To understand ADM is to understand also how personal attitudes can influence decision-making and how those attitudes can be modified to enhance safety in the flight deck. It is important to understand the factors that cause humans to make decisions and how the decision-making process not only works, but also can be improved.

This chapter focuses on helping the pilot improve his or her ADM skills with the goal of mitigating the risk factors associated with flight. Advisory Circular (AC) 60-22, Aeronautical Decision Making, provides background references, definitions, and other pertinent information about ADM training in the general aviation (GA) environment. [Figure 5-1]

## History of ADM

For over 25 years, the importance of good pilot judgment, or ADM, has been recognized as critical to the safe operation of aircraft, as well as accident avoidance. Research in this area prompted the Federal Aviation Administration (FAA) to produce training directed at improving the decision-making of pilots and led to current FAA regulations that require that decision-making be taught as part of the pilot training curriculum. ADM research, development, and testing culminated in 1987 with the publication of six manuals oriented to the decision-making needs of variously rated pilots. These manuals provided multifaceted materials designed to reduce the number of decision-related accidents. The effectiveness of these materials was validated in independent studies where student pilots received such training in conjunction with the standard flying curriculum. When tested, the pilots who had received ADM training made fewer in-flight errors than those who had not received ADM training. The differences were statistically significant and ranged from about 10 to 50 percent fewer judgment errors. In the operational environment, an operator flying about 400,000 hours annually demonstrated a 54 percent reduction in accident rate after using these materials for recurrency training.

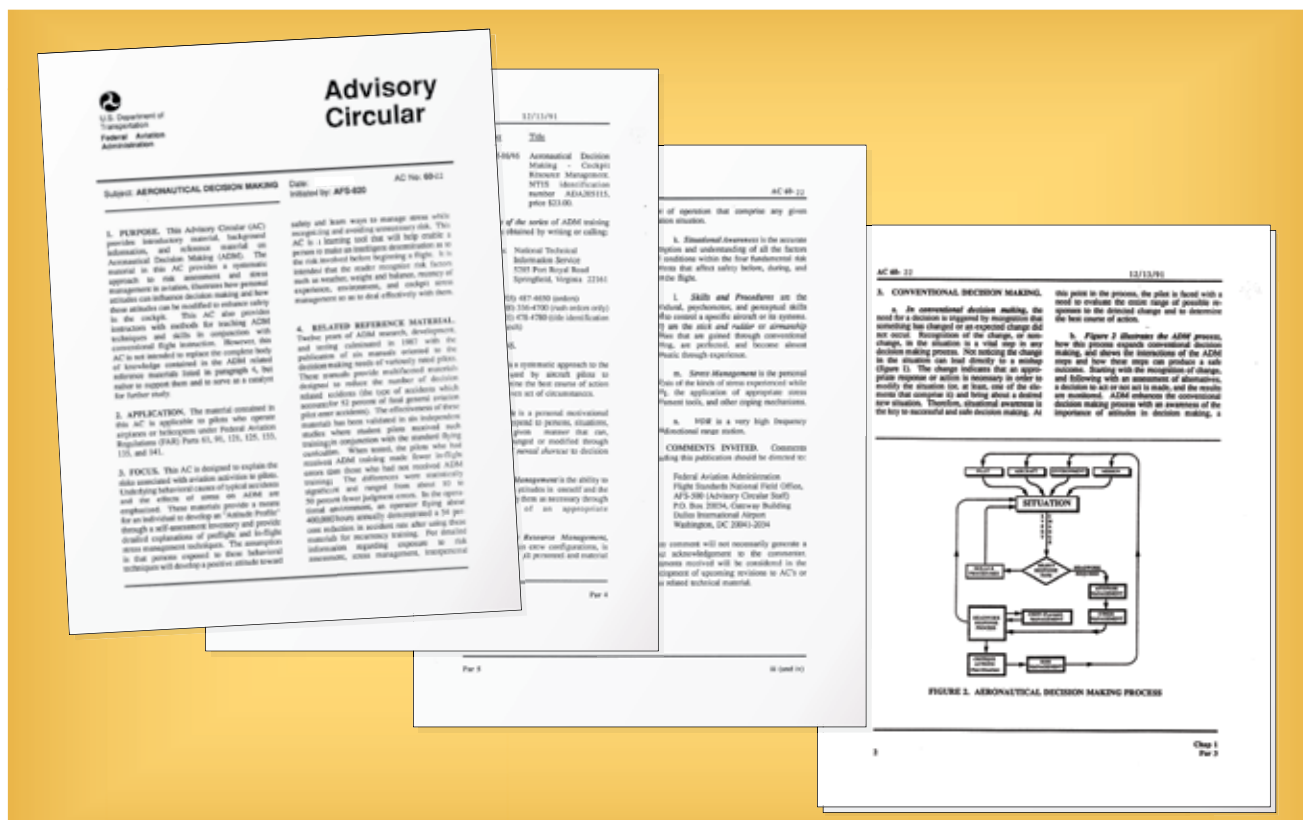


Figure 5-1. Advisory Circular (AC) 60-22, Aeronautical Decision Making, carries a wealth of information for the pilot to learn.

Contrary to popular belief, good judgment can be taught. Tradition held that good judgment was a natural by-product of experience, and as pilots continued to log accident-free flight hours, a corresponding increase of good judgment was assumed. Building upon the foundation of conventional decision-making, ADM enhances the process to decrease the probability of human error and increase the probability of a safe flight. ADM provides a structured, systematic approach to analyzing changes that occur during a flight and how these changes might affect a flight's safe outcome. The ADM process addresses all aspects of decision-making in the flight deck and identifies the steps involved in good decision-making.

Steps for good decision-making are:

1. Identifying personal attitudes hazardous to safe flight.
2. Learning behavior modification techniques.
3. Learning how to recognize and cope with stress.
4. Developing risk assessment skills.
5. Using all resources.
6. Evaluating the effectiveness of one's ADM skills.

ADM results in helping to manage risk. When a pilot follows good decision-making practices, the inherent risk in a flight is reduced or even eliminated. The ability to make good decisions is based upon direct or indirect experience and education.

Consider automobile seat belt use. In just two decades, seat belt use has become the norm, placing those who do not wear seat belts outside the norm, but this group may learn to wear a seat belt by either direct or indirect experience. For example, a driver learns through direct experience about the value of wearing a seat belt when he or she is involved in a car accident that leads to a personal injury. An indirect learning experience occurs when a loved one is injured during a car accident because he or she failed to wear a seat belt.

While poor decision-making in everyday life does not always lead to tragedy, the margin for error in aviation is narrow. Since ADM enhances management of an aeronautical environment, all pilots should become familiar with and employ ADM.

## Analytical Decision-Making

Analytical decision-making is a form of decision-making that takes both time and evaluation of options. A form of this type of decision-making is based upon the acronym "DECIDE." It provides a six-step process for the pilot to logically make good aeronautical decisions. For example, a pilot who flew

from Houston, Texas to Jacksonville, Florida in a Merlin failed to use the decision-making process correctly and to his advantage. Noteworthy about this example is how easily pilots are swayed from taking best courses of action when convenient courses are interpreted as being in our best interest.

**Detect a change or hazard.** In the case at hand, the pilot was running late after conducting business meetings early in the morning. He and his family departed one hour later than expected. In this case, one would assess the late departure for impact to include the need to amend the arrival time. However, if the pilot is impetuous, these circumstances translate into a hazard. Because this pilot was in a hurry, he did not assess for impact and, as a result, did not amend the arrival time. Key in any decision-making is detecting the situation and its subtleties as a hazard; otherwise, no action is taken by the pilot. It is often the case that the pilot fails to see the evolving hazard. On the other hand, a pilot who does see and understand the hazard, yet makes a decision to ignore it, does not benefit from a decision-making process; the issue is not understanding decision-making, but one of attitude.

**Estimate the need to counter or react to the change.** As the pilot progressed to the destination, it became apparent that the destination weather (at Craig Field in Jacksonville) was forecast as below approach minimums (due to fog) at the time of arrival. However, weather at an alternative airport just 40 miles away was visual flight rules (VFR). At this time, the pilot should have assessed several factors to include the probability of making a successful approach and landing at Craig versus using an alternative field. In one case, the approach is certainly challenging, but it is an approach at the intended destination. The other location (unencumbered by weather) is inconvenient to the personnel waiting on the ground, requiring that they drive 40 miles to meet the pilot and his family.

**Choose a desirable outcome for the flight.** Selecting a desirable outcome requires objectivity, and this is when pilots make grave errors. Instead of selecting the course of outcome with consideration to challenges of airmanship, pilots typically select an outcome that is convenient for both themselves and others. And without other onboard or external input, the choice is not only flawed but also reinforced by their own rationale. In this case, the pilot of the Merlin intends to make the approach at Craig despite 100 foot ceilings with ¼ mile visibility.

**Identify actions that can successfully control the change.** In the situation being discussed, the pilot looks at success as meeting several objectives:

1. Being on time for Thanksgiving dinner



2. Not inconveniencing his relatives waiting on the ground
3. Meeting his own predisposed objective of landing at Craig

The pilot failed to be objective in this case. The identification of courses of action were for his psychological success and not the safety of his family.

**Do take the necessary action.** In this case, the pilot contaminates his decision-making process and selects an approach to the instrument landing system (ILS) runway 32 at Craig where the weather was reported and observed far below the minimums.

**Evaluate the effect of the action.** In many cases like this, the pilot is so sure of his or her decision that the evaluation phase of his or her action is simply on track and on glideslope, despite impossible conditions. Because the situation seems in control, no other evaluation of the progress is employed.

The outcome of this accident was predictable considering the motivation of the pilot and his failure to monitor the approach using standard and accepted techniques. It was ascertained that the pilot, well above the decision height, saw a row of lights to his right that was interpreted as the runway environment. Instead of confirming with his aircraft's situational position, the pilot instead took over manually and flew toward the lights, descended below the glidepath, and impacted terrain. The passengers survived, but the pilot was killed.

## Automatic Decision-Making

In an emergency situation, a pilot might not survive if he or she rigorously applied analytical models to every decision made; there is not enough time to go through all the options. But under these circumstances, does he or she find the best possible solution to every problem?

For the past several decades, research into how people actually make decisions has revealed that when pressed for time, experts faced with a task loaded with uncertainty, first assess whether the situation strikes them as familiar. Rather than comparing the pros and cons of different approaches, they quickly imagine how one or a few possible courses of action in such situations will play out. Experts take the first workable option they can find. While it may not be the best of all possible choices, it often yields remarkably good results.

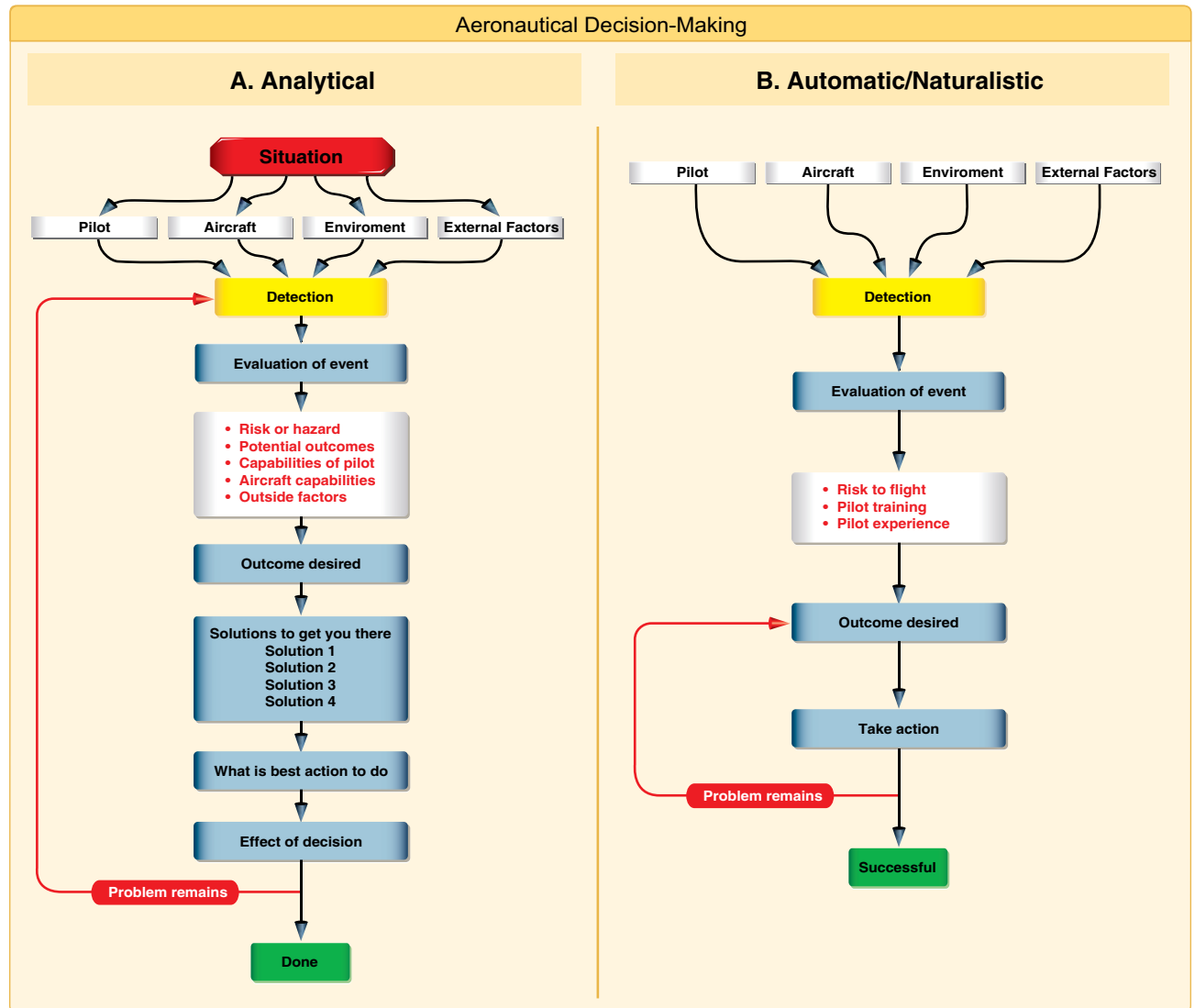
The terms naturalistic and automatic decision-making have been coined to describe this type of decision-making. These processes were pioneered by Mr. Gary Klein, a research psychologist famous for his work in the field of automatic/naturalistic decision-making. He discovered that laboratory models of decision-making could not describe decision-making under uncertainty and fast dynamic conditions. His processes have influenced changes in the ways the Marines and Army train their officers to make decisions and are now impacting decision-making as used within the aviation environment. The ability to make automatic decisions holds true for a range of experts from fire fighters to police officers. It appears the expert's ability hinges on the recognition of patterns and consistencies that clarify options in complex situations. Experts appear to make provisional sense of a situation, without actually reaching a decision, by launching experience-based actions that in turn trigger creative revisions.

This is a reflexive type of decision-making anchored in training and experience and is most often used in times of emergencies when there is no time to practice analytical decision-making. Naturalistic or automatic decision-making improves with training and experience, and a pilot will find himself or herself using a combination of decision-making tools that correlate with individual experience and training. *Figure 5-2* illustrates the differences between traditional, analytical decision-making and naturalistic decision-making, both related to human behavior. Instances of human factor accidents include operational errors that relate to loss of situational awareness and flying outside the envelope. These can be termed as operational pitfalls.

## Operational Pitfalls

Operational pitfalls are traps that pilots fall into, avoidance of which is actually simple in nature. A pilot should always have an alternate flight plan for where to land in case of an emergency on every flight. For example, a pilot may decide to spend a morning flying the traffic pattern but does not top off the fuel tanks because he or she is only flying the traffic pattern. Make considerations for the unexpected. What if another aircraft blows a tire during landing and the runway is closed? What will the pilot in the traffic pattern do? Although the odds may be low for something of this nature to happen, every pilot should have an alternate plan that answers the question, "Where can I land?" and the follow-up question, "Do I have enough fuel?"

Weather is the largest single cause of aviation fatalities. Most of these accidents occur to a GA operator, usually flying a light single- or twin-engine aircraft, who encounters



### The DECIDE Model

- 1. Detect.** The decision maker detects the fact that change has occurred.
- 2. Estimate.** The decision maker estimates the need to counter or react to the change.
- 3. Choose.** The decision maker chooses a desirable outcome (in terms of success) for the flight.
- 4. Identify.** The decision maker identifies actions which could successfully control the change.
- 5. Do.** The decision maker takes the necessary action.
- 6. Evaluate.** The decision maker evaluates the effect(s) of his/her action countering the change.

**Figure 5-2.** The illustration on the left shows how the DECIDE model is used in decision-making and follows the five steps shown in the above left. In the automatic decision-making model (sometimes called naturalistic decision-making) the emphasis is recognizing a problem paired with a solution that is cultivated through both experience and training. In theory the automatic decision-making model seeks a quick decision at the cost of absolute accuracy where prolonged analysis is not practical. Naturalistic decision-making is generally used during emergencies where slow responsiveness is problematic and potentially additive to a problem.

instrument meteorological conditions (IMC) conditions while operating under VFR. Over half the pilots involved in weather accidents did not receive an official weather briefing. Once the flight is under way, the number of pilots who receive a weather update from automated flight service station (AFSS) is dismal. An analysis done by FAA's Aviation Safety Information Analysis System (ASIAS) found that during a recent five-year period, only 19 pilots out of 586 fatal accident flights received any information from flight watch or an AFSS, once en route. It is important to recognize weather presents a hazard, which in turn can become an unmanageable risk. GA aircraft travel slowly and must fly in the weather rather than above it. Since weather is unpredictable, it is highly likely that during a flight, a pilot will encounter weather conditions different from what he or she expected. These weather conditions are not necessarily severe, like ice or thunderstorms, and analysis has shown that most VFR encounters with IMC involved low clouds and restrictions to visibility.

### **Scud Running**

Scud running, or continued VFR flight into instrument flight rules (IFR) conditions, pushes the pilot and aircraft capabilities to the limit when the pilot tries to make visual contact with the terrain. This is one of the most dangerous things a pilot can do and illustrates how poor ADM links directly to a human factor that leads to an accident. A number of instrument-rated pilots die scud running while operating VFR. Scud running is seldom successful, as can be seen in the following accident report.

A Cessna 172C, piloted by a commercial pilot, was substantially damaged when it struck several trees during a precautionary landing on a road. Instrument meteorological conditions (IMC) prevailed at the time of the accident. The personal cross-country flight was being conducted without a flight plan.

The pilot had purchased the airplane in Arkansas and was ferrying it to his fixed base operation (FBO) in Utah. En route stops were made and prior to departing the last stop, the pilot, in a hurry and not wanting to walk back to the FBO to call flight service, discussed the weather with a friend who told the pilot that the weather was clear to the north. Poor weather conditions prevented him from landing at his original destination, so the pilot turned around and landed at a privately owned airport with no service facilities. Shortly thereafter, the pilot took off again and looped north toward his destination. The "weather got bad" and the pilot decided to make a precautionary landing on a snow-covered road. The road came to a "T" and the airplane slid off the end. The left wing and propeller struck the ground and the right wing struck a tree. The right wing had leading edge compression

damage outboard of the root, and the left wing leading edge was crushed near the wing tip fairing. Both propeller blades were bent. As discussed throughout this handbook, this accident was the result of a chain of poor decisions. The pilot himself recalled what he should have done in this situation, "I should have picked a spot to do a precautionary landing sooner before the weather got bad. Second, I should have called flight service to get a weather briefing, instead of discussing it with a friend on the ramp."

### **Get-There-Itis**

In get-there-itis, personal or external pressure clouds the vision and impairs judgment by causing a fixation on the original goal or destination combined with a total disregard for alternative course of action.

"I have to be in Houston by 7 o'clock." In the previous case, the pilot was simply lazy.

Approximately 15 minutes after departure, the pilot of a Piper PA-34-200T twin-engine airplane encountered IMC. The non-instrument-rated private pilot lost control of the airplane and impacted snow-covered terrain. Prior to the cross-country flight, the pilot obtained three standard weather briefings, of which two were obtained on the previous day and one on the morning of the accident. The briefings included IFR conditions along the planned route of flight.

According to the briefing and a statement from a friend, the pilot intended to land the airplane prior to his destination if the weather conditions were not visual flight rules (VFR). The pilot would then "wait it out" until the weather conditions improved. According to radar data, the airplane departed from the airport and was traveling on a southeasterly heading. For the first 15 minutes of the flight, the airplane maintained a level altitude and a consistent heading. For the last minute of the flight, the airplane entered a descent of 2,500 feet per minute (fpm), a climb of 3,000 fpm, a 1,300 fpm descent, and the airplane's heading varied in several degrees. The airplane impacted the terrain in a right wing low, nose-down attitude.

Looking beyond the summary, get-there-itis leads to a poor aeronautical decision because this pilot repeatedly sought weather briefings for a VFR flight from Pueblo, Colorado, to Tyler, Texas. During a 17-minute briefing at 0452, he was informed of weather conditions along his planned route of flight that included IFR conditions that were moving south, moderate icing conditions for the state of Colorado, and low ceilings of visibility along the planned route of flight. His next call took place at 0505, approximately 1½ hours prior to takeoff. The pilot responded to the reported weather conditions by saying "so I've got a, I've got a little tunnel

there that looks decent right now...from what that will tell me I've got a, I've got an open shot over the butte."

The pilot began the flight 1½ hours after his weather update, neglecting to weigh the risks created by a very volatile weather situation developing across the state.

The National Transportation Safety Board (NTSB) determined the probable cause of this accident was the pilot's failure to maintain control of the airplane after an inadvertent encounter with IMC, resulting in the subsequent impact with terrain. Contributing factors were the pilot's inadequate preflight planning, self-induced pressure to conduct the flight, and poor judgment.

Unfortunately for this pilot, he fell into a high-risk category. According to the NTSB, pilots on flights of more than 300 nautical miles (NM) are 4.7 times more likely to be involved in an accident than pilots on flights of 50 NM or less. Another statistic also put him in to the potential accident category: his lack of an instrument rating. Studies have found that VFR pilots are trained to avoid bad weather and when they find themselves in poor weather conditions, they do not have the experience to navigate their way through it.

### **Continuing VFR into IMC**

Continuing VFR into IMC often leads to spatial disorientation or collision with ground/obstacles. It is even more dangerous when the pilot is not instrument rated or current. The FAA and NTSB have studied the problem extensively with the goal of reducing this type of accident. Weather-related accidents, particularly those associated with VFR flight into IMC, continue to be a threat to GA safety because 80 percent of the VFR-IMC accidents resulted in a fatality.

One question frequently asked is whether or not pilots associated with VFR flight into IMC even knew they were about to encounter hazardous weather. It is difficult to know from accident records exactly what weather information the pilot obtained before and during flight, but the pilot in the following accident departed in marginal visual meteorological conditions (VMC).

In 2007, a Beech 836 TC Bonanza was destroyed when it impacted terrain. The private, non-instrument-rated pilot departed in VMC on a personal flight and requested VFR flight following to his destination. When he neared his destination, he contacted approach control and reported that his altitude was 2,500 feet above mean sea level (MSL). Approach control informed the pilot that there were moderate to heavy rain showers over the destination airport. The pilot reported that he was experiencing "poor visibility" and was considering turning 180° to "go back." Approach control informed the

pilot that IMC prevailed north of his position with moderate to heavy rain showers. Their exchange follows:

At 1413:45, approach control asked the pilot if he was going to reverse course. The pilot replied, "Ah, affirmative, yeah we're gonna make, we're gonna actually head, ah, due north."

Approach control instructed the pilot to proceed to the northeast and maintain VFR.

At 1414:53, approach control asked the pilot what was his current destination. The pilot responded, "We're deviating. I think we're going to go back over near Eau Claire, but, ah, we're going to see what the weather is like. We're, we're kinda in the soup at this point so I'm trying to get back, ah, to the east."

At 1415:10, approach control informed the pilot that there was "some level one rain or some light rain showers" that were about seven miles ahead of his present position.

At 1415:30, the pilot asked approach control, "What is the ah, ah, Lakeville weather? I was showing seven thousand and overcast on the system here. Is that still holding?"

Approach control responded, "No, around [the] Minneapolis area we're overcast at twenty three hundred and twenty one hundred in the vicinity of all the other airports around here."

At 1415:49, the pilot stated, "I'm going to head due south at this time, down to, ah, about two thousand and make it into Lakeville."

Approach control responded, "...you can proceed south bound."

At 1416:02, the pilot responded, "...thanks (unintelligible)."

The radar data indicated that the airplane's altitude was about 2,600 feet MSL.

There were no further radio transmissions. After the last radio transmission, three radar returns indicated the airplane descended from 2,500 feet to 2,300 feet MSL before it was lost from radar contact.

A witness reported he heard an airplane and then saw the airplane descending through a cloud layer that was about 400–500 feet above the ground. The airplane was in about a 50° nose-down attitude with its engine producing "cruise power." He reported the airplane was flying at a high rate of speed for about four seconds until he heard the airplane

impact the terrain. The observed weather in the area of the accident was reported as marginal VMC and IMC.

The NTSB determined the probable cause(s) of this accident to be the pilot's continued flight into IMC, which resulted in spatial disorientation and loss of control.

Research can offer no single explanation to account for this type of accident. Is it the end result of poor situational awareness, hazardous risk perception, motivational factors, or simply improper decision-making? Or is it that adequate weather information is unavailable, simply not used, or perhaps not understood? Extracting critical facts from multiple sources of weather information can be challenging for even the experienced aviator. And once the pilot is in the air, en route weather information is available only to the extent that he or she seeks it out if their aircraft is not equipped with operational weather displays.

No one has yet determined why a pilot would fly into IMC when limited by training to fly under VFR. In many cases, the pilot does not understand the risk. Without education, we have a fuzzy perception of hazards. It should be noted that pilots are taught to be confident when flying. Did overconfidence and ability conflict with good decision-making in this accident? Did this pilot, who had about 461 flight hours, but only 17 hours in make and model overrate his ability to fly this particular aircraft? Did he underestimate the risk of flying in marginal VFR conditions?

### **Loss of Situational Awareness**

Situational awareness is the accurate perception and understanding of all the factors and conditions within the four fundamental risk elements (pilot, aircraft, environment, and type of operation) that affect safety before, during, and after the flight. Thus, loss of situational awareness results in a pilot not knowing where he or she is, an inability to recognize deteriorating circumstances, and the misjudgment of the rate of deterioration.

In 2007, an instrument-rated commercial pilot departed on a cross-country flight through IMC. The pilot made radio transmissions to ground control, tower, low radar approach control, and high radar approach control that he was "new at instruments" and that he had not flown in IMC "in a long time." While maneuvering to get back on the centerline of the airway, while operating in an area of heavy precipitation, the pilot lost control of the airplane after he became spatially disoriented.

Recorded radar data revealed flight with stable parameters until approximately 1140:49 when the airplane is recorded making an unexpected right turn at a rate of 2° per second.

The pilot may not have noticed a turn at this rate since there were no radar calls to departure control. The right turn continues until radar contact is lost at 1141:58 at which point that airplane is turning at a rate of approximately 5° per second and descending at over 3,600 fpm.

Wreckage and impact information was consistent with a right bank, low-angle, high-speed descent. IMC prevailed in the area at the time of the accident. The descent profile was found to be consistent with the "graveyard spiral." Prior to flight, for unknown reasons, the telephone conversations with the AFSS progressed from being conservative to a strong desire to fly home, consistent with the pilot phenomena "get-home-itis."

The 26 year old pilot was reported to have accumulated a total of 456.7 hours, of which 35.8 hours were in the same make and model. Prior to the accident flight, the pilot had accumulated a total of 2.5 hours of actual instrument time, with 105.7 hours of simulated instrument time.

The following abbreviated excerpt from the accident report offers insight into another example of poor aeronautical decision-making.

The pilot had telephoned AFSS six times prior to take off to request weather reports and forecasts. The first phone call lasted approximately 18 minutes during which time the AFSS briefer forecasts IMC conditions for the route of flight and briefs an airmen's meteorological information (AIRMET) for IFR conditions. The pilot stated that he did not try to take off a day earlier because he recalled that his instrument flight instructor told him not to take off if he did not feel comfortable.

During the second phone call, the pilot stated he was instrument rated but did not want to take any chances. At this time, the AFSS briefer forecast light rain and marginal conditions for VFR. The third phone call lasted approximately 5 minutes during which the AFSS briefer gives weather, the AIRMET, and forecasts a cycle of storms for the day of flight. The pilot responds that it sounds like a pretty bad day to fly. During the fourth phone call, the pilot states that he has been advised by a flight instructor at his destination airport that he should try to wait it out because the weather is "pretty bad right now" The AFSS briefer agrees and briefs light to moderate rain showers in the destination area and the AIRMET for IFR conditions. The AFSS briefer states that after 1100 the weather should improve.

At 1032, the pilot calls AFSS again and sounds distressed. The pilot stated he wants to get home, has not showered in 1½ days, is getting tired, and wants to depart as soon as possible.



The AFSS briefer briefs the AIRMET for IFR conditions and forecasts IFR en route. At 1055, the pilot phones AFSS for the final time and talks for approximately 7 minutes. Then, he files an IFR flight plan. The AFSS briefer states improving conditions and recommends delaying departure to allow conditions to improve. However, this pilot made the decision to fly in weather conditions clearly outside his personal flying comfort zone. Once he had exceeded his proficiency level, the newly minted instrument pilot had no instructor in the other seat to take over.

The NTSB determines the probable cause of this accident to be pilot loss of control due to spatial disorientation. Contributing factors were the pilot's perceived need to fly to home station and his lack of flight experience in actual IMC.

### **Flying Outside the Envelope**

Flying outside the envelope is an unjustified reliance on the mistaken belief that the airplane's high performance capability meets the demands imposed by the pilot's (usually overestimated) flying skills. While it can occur in any type aircraft, advanced avionics aircraft have contributed to an increase in this type accident.

According to the Aircraft Owners and Pilots Association (AOPA) Air Safety Foundation (ASF), advanced avionics aircraft are entering GA fleet in large numbers. Advanced avionics aircraft includes a variety of aircraft from the newly designed to retrofitted existing aircraft of varying ages. What they all have in common are complex avionics packages. While advanced avionics aircraft offer numerous safety and operational advantages, the FAA has identified a safety issue that concerns pilots who develop an unwarranted overreliance on the avionics and the aircraft, believing the equipment will compensate fully for pilot shortcomings.

Related to overreliance is the role of ADM, which is probably the most significant factor in the GA accident record of high-performance aircraft used for cross-country flight. The FAA advanced avionics aircraft safety study found that poor decision-making seems to afflict new advanced avionics aircraft pilots at a rate higher than for GA as a whole. This is probably due to increased technical capabilities, which tempt pilots to operate outside of their personal (or even legal) limits. The availability of global positioning system (GPS) and moving map systems, coupled with traffic and near real-time weather information in the flight deck, may lead pilots to believe they are protected from the dangers inherent to operating in marginal weather conditions.

While advanced flight deck technologies may mitigate certain risks, it is by no means a substitute for sound ADM. The

challenge is this: How should a pilot use this new information in flight to improve the safety of flight operations? The answer to this question lies in how well the pilot understands the information, its limitations, and how best to integrate this data into the ADM process.

According to AOPA, government information gathering on accidents does not contain definitive ways to differentiate between advanced avionics aircraft and non-advanced avionics aircraft; however, it is known that the aircraft in the following accident was an advanced avionics aircraft.

In 2003, during a cross-country flight, the non-instrument-rated private pilot encountered heavy fog and poor visibility. The airplane was destroyed after impacting the terrain in a wildlife refuge. Wildlife refuge personnel stated the weather was clear on the morning of the accident. However, later that morning, the weather deteriorated, and the wildlife refuge personnel stated, "the fog was very heavy and visibility was very poor."

An AIRMET, issued and valid for the area, reported the following: "occasional ceiling below 1,000 feet, visibility below 3 miles in mist, fog ... Mountains occasionally obscured clouds, mist, fog ..." On the day of the accident, the pilot did not file a flight plan or receive a formal weather briefing from an AFSS.

Examining this accident in more detail offers insight into the chain of events that led to this accident.

1. On the morning of the flight, the pilot used the Internet to complete three sessions with the Direct User Access Terminal Service (DUATS), filing his VFR flight plan during the third session. He departed in VFR conditions and requested and received VFR flight following until he approached a mountain range at which point he canceled his flight following services and continued en route without further FAA contact.
2. During the last leg of his flight, the pilot initiated a right turn of about 120°. This turn, which he initiated about 3,600 feet MSL, resulted in the aircraft flying along a narrow valley toward up-sloping terrain. The pilot continued in that direction for another 2 minutes before colliding with a number of trees near the top of a ridge.

The NTSB determines the probable cause(s) of this accident as follows: The pilot's inadvertent flight into IMC and failure to maintain clearance with the terrain. A contributing factor

was the pilot's failure to obtain an updated preflight weather briefing.

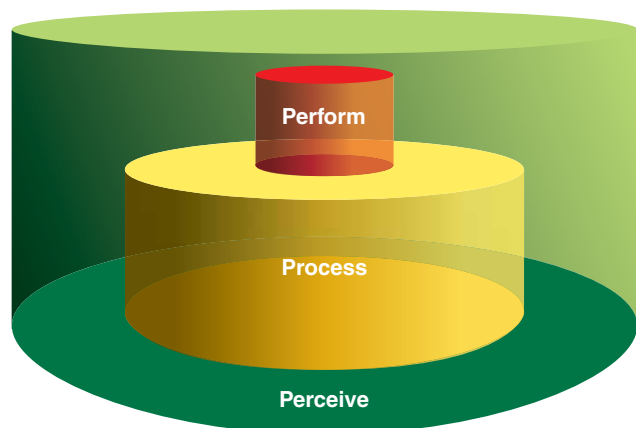
The ASF offered the following comment for educational purposes: the non-instrument-rated pilot in this accident may or may not have been tempted to continue his flight when encountering IMC conditions because he had advanced avionics aircraft equipment on board.

### 3P Model

Making a risk assessment is important, but in order to make any assessment the pilot must be able to see and sense surroundings and process what is seen before performing a corrective action. An excellent process to use in this scenario is called the 3 Ps: Perceive, Process, and Perform.

The Perceive, Process, Perform (3P) model for ADM offers a simple, practical, and systematic approach that can be used during all phases of flight. [Figure 5-3] To use it, the pilot will:

- Perceive the given set of circumstances for a flight.
- Process by evaluating their impact on flight safety.
- Perform by implementing the best course of action.



**Figure 5-3.** The 3P model: Perceive, Process, and Perform.

Examine a pilot flying into a canyon. Many pilots fail to see the difference between a valley and a canyon. Most valleys can be characterized as depressions with a predominant direction. A canyon is also a valley, but it is a very deep valley bordered by cliffs. One can infer that making a turn across a valley will be over rising terrain whose slope is shallow. A canyon, however, is bordered by vertical walls. Additionally, valleys are typically wider than canyons. However, before proceeding it is important to understand the relationship between rate of turn and turn radius.

### Rate of Turn

The rate of turn (ROT) is the number of degrees (expressed in degrees per second) of heading change that an aircraft makes. The ROT can be determined by taking the constant of 1,091, multiplying it by the tangent of any bank angle and dividing that product by a given airspeed in knots as illustrated in Figure 5-4. If the airspeed is increased and the ROT desired is to be constant, the angle of bank must be increased; otherwise, the ROT decreases. Likewise, if the airspeed is held constant, an aircraft's ROT increases if the bank angle is increased. The formula in Figures 5-4 through 5-6 depicts the relationship between bank angle and airspeed as they affect the ROT.

$$\text{ROT} = \frac{1,091 \times \text{tangent of the bank angle}}{\text{airspeed (in knots)}}$$

**Example** The rate of turn for an aircraft in a coordinated turn of 30° and traveling at 120 knots would have a ROT as follows.

$$\text{ROT} = \frac{1,091 \times \text{tangent of } 30^\circ}{120 \text{ knots}}$$

$$\text{ROT} = \frac{1,091 \times 0.5773 (\text{tangent of } 30^\circ)}{120 \text{ knots}}$$

$$\text{ROT} = 5.25 \text{ degrees per second}$$

**Figure 5-4.** Rate of turn for a given airspeed (knots, TAS) and bank angle.

**Example** Suppose we were to increase the speed to 240 knots, what is the rate of turn? Using the same formula from above we see that:

$$\text{ROT} = \frac{1,091 \times \text{tangent of } 30^\circ}{240 \text{ knots}}$$

$$\text{ROT} = 2.62 \text{ degrees per second}$$

An increase in speed causes a decrease in the rate of turn when using the same bank angle.

**Figure 5-5.** Rate of turn when increasing speed.

NOTE: All airspeeds discussed in this section are true airspeed (TAS).

Airspeed significantly affects an aircraft's ROT. If airspeed is increased, the ROT is reduced if using the same angle of bank used at the lower speed. Therefore, if airspeed is increased as illustrated in Figure 5-5, it can be inferred that the angle of bank must be increased in order to achieve the same ROT achieved in Figure 5-6.

**Example** Suppose we wanted to know what bank angle would give us a rate of turn of 5.25° per second at 240 knots. A slight rearrangement of the formula would indicate it will take a 49° angle of bank to achieve the same ROT used at the lower airspeed of 120 knots.

$$\text{ROT (5.25)} = \frac{1,091 \times \text{tangent of } X}{240 \text{ knots}}$$

$$240 \times 5.25 = 1,091 \times \text{tangent of } X$$

$$\frac{240 \times 5.25}{1,091} = \text{tangent of } X$$

$$1.1549 = \text{tangent of } X$$

$$49^\circ = X$$

**Figure 5-6.** To achieve the same rate of turn of an aircraft traveling at 120 knots, an increase of bank angle is required.

What does this mean on a practicable side? If a given airspeed and bank angle produces a specific ROT, additional conclusions can be made. Knowing the ROT is a given number of degrees of change per second, the number of seconds it takes to travel 360° (a circle) can be determined by simple division. For example, if moving at 120 knots with a 30° bank angle, the ROT is 5.25° per second and it takes 68.6 seconds (360° divided by 5.25 = 68.6 seconds) to make a complete circle. Likewise, if flying at 240 knots TAS and using a 30° angle of bank, the ROT is only about 2.63° per second and it takes about 137 seconds to complete a 360° circle. Looking at the formula, any increase in airspeed is directly proportional to the time the aircraft takes to travel an arc.

So, why is this important to understand? Once the ROT is understood, a pilot can determine the distance required to make that particular turn, which is explained in radius of turn.

### Radius of Turn

The radius of turn is directly linked to the ROT, which is a function of both bank angle and airspeed, as explained earlier. If the bank angle is held constant and the airspeed is increased, the radius of the turn changes (increases). A higher airspeed causes the aircraft to travel through a longer arc due to a greater speed. An aircraft traveling at 120 knots is able to turn a 360° circle in a tighter radius than an aircraft traveling at 240 knots. In order to compensate for the increase in airspeed, the bank angle would need to be increased.

The radius of turn (ROT) can be computed using a simple formula. The radius of turn is equal to the velocity squared (V<sup>2</sup>) divided by 11.26 times the tangent of the bank angle.

$$R = \frac{V^2}{11.26 \times \text{tangent of the bank angle}}$$

Using the examples provided in *Figures 5-4* through *5-6*, both the radii of the two speeds postulated can be computed. Noteworthy, is if the speed is doubled, the radius is squared. [*Figures 5-7 and 5-8*]

120 knots

$$R = \frac{V^2}{11.26 \times \text{tangent of bank angle}}$$

$$R = \frac{120^2}{11.26 \times \text{tangent of } 30^\circ}$$

$$R = \frac{14,400}{11.26 \times 0.5773}$$

$$R = 2,215 \text{ feet}$$

The radius of a turn required by an aircraft traveling at 120 knots and using a bank angle of 30° is 2,215 feet.

**Figure 5-7.** Radius at 120 knots.

240 knots

$$R = \frac{V^2}{11.26 \times \text{tangent of bank angle}}$$

$$R = \frac{240^2}{11.26 \times \text{tangent of } 30^\circ}$$

$$R = \frac{57,600}{11.26 \times 0.57735}$$

$$R = 8,861 \text{ feet}$$

(four times the radius at 120 knots)

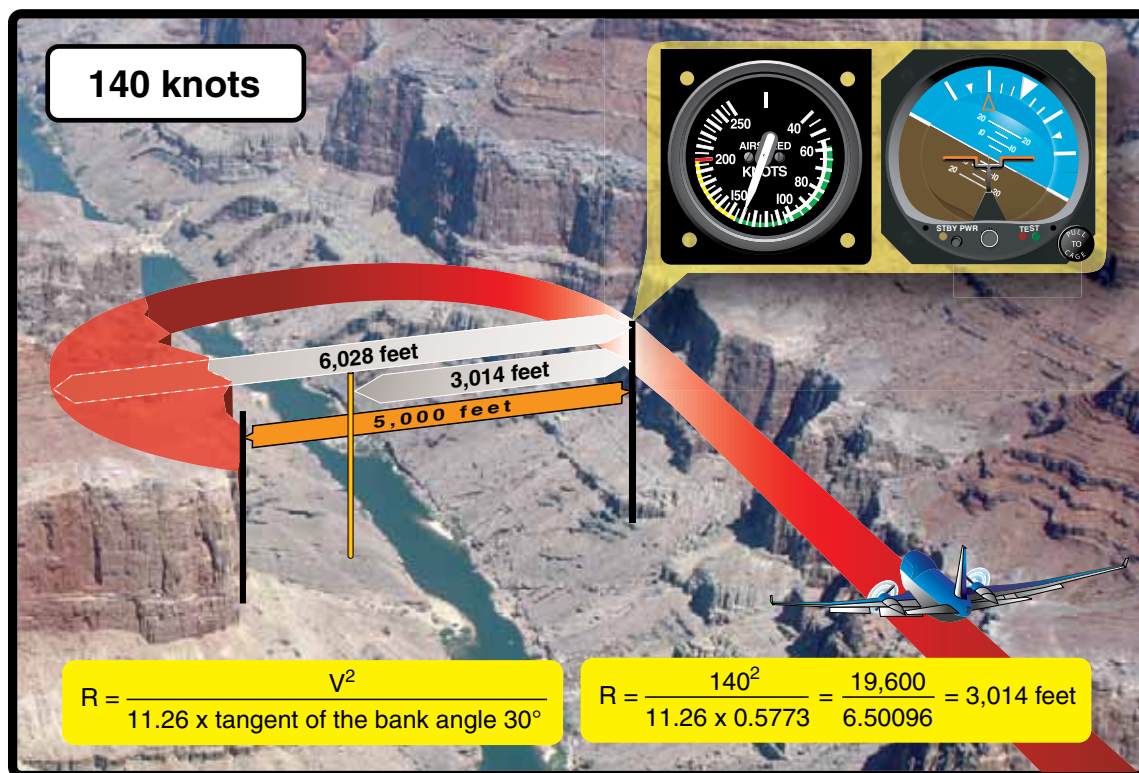
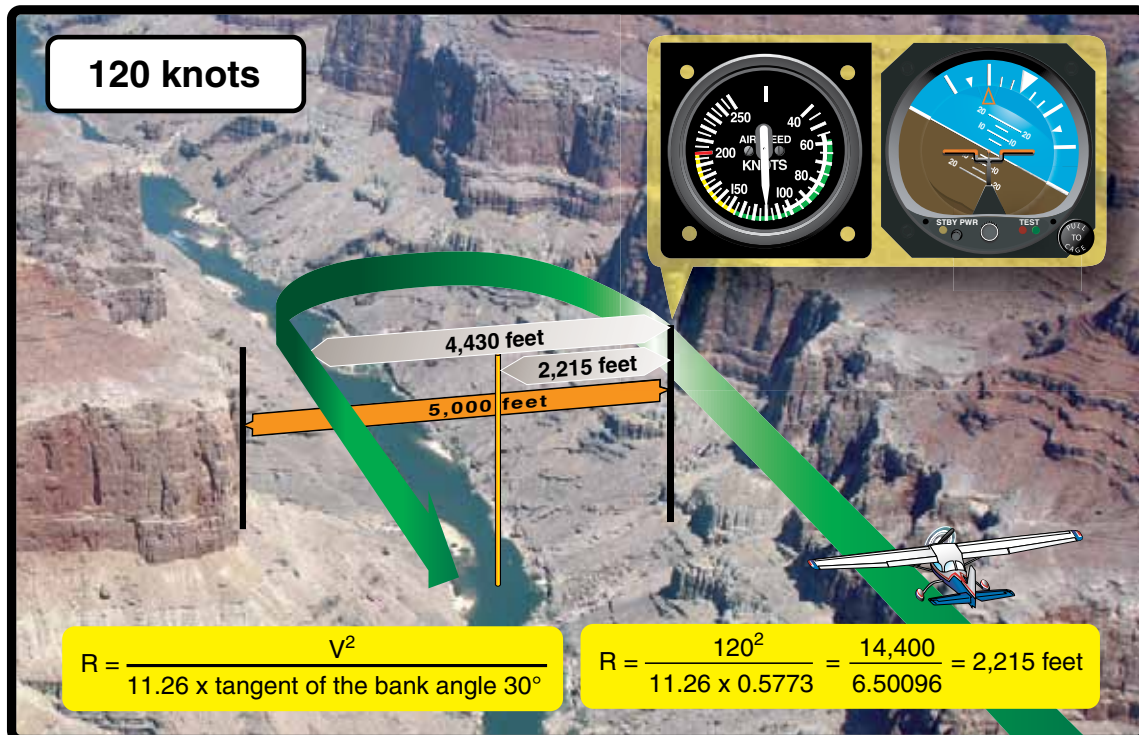
The radius of a turn required by an aircraft traveling at 240 knots using the same bank angle in *Figure 4-51* is 8,861 feet. Speed is a major factor in a turn.

**Figure 5-8.** Radius at 240 knots.

In *Figure 5-9*, two aircraft enter a canyon. One aircraft enters at 120 knots, and the other at 140 knots. Both pilots realize they are in a blind canyon and need to conduct a course reversal. Both pilots perceive their unique environment and sense that something is occurring. From this perception, the pilots process the information, and then act. Although one may sense that this is similar to the DECIDE model, it is not. The 3P process is a continuous loop of the pilot's handling of hazards. The DECIDE model and naturalistic decision-making focus on particular problems requiring resolution. Therefore, pilots exercise the 3P process continuously, while the DECIDE model and naturalistic decision-making result from the 3P process.

### Perceive

In the first step, the goal is to develop situational awareness by perceiving hazards, which are present events, objects, or circumstances that could contribute to an undesired future event. Both pilots realize they need to turn 180° for continued safe flight. The pilot systematically identifies and lists hazards associated with all aspects of the situation, and must do it fast and accurately.



**Figure 5-9.** Two aircraft have flown into a canyon by error. The canyon is 5,000 feet across and has sheer cliffs on both sides. The pilot in the top image is flying at 120 knots. After realizing the error, the pilot banks hard and uses a 30° bank angle to reverse course. This aircraft requires about 4,000 feet to turn 180°, and makes it out of the canyon safely. The pilot in the bottom image is flying at 140 knots and also uses a 30° angle of bank in an attempt to reverse course. The aircraft, although flying just 20 knots faster than the aircraft in the top image, requires over 6,000 feet to reverse course to safety. Unfortunately, the canyon is only 5,000 feet across and the aircraft will hit the canyon wall. The point is that airspeed is the most influential factor in determining how much distance is required to turn. Many pilots have made the error of increasing the steepness of their bank angle when a simple reduction of speed would have been more appropriate.



## Process

In the second step, the goal is to process learned and practiced information to determine whether the identified hazards constitute risk, which is defined as the future impact of a hazard that is not controlled or eliminated. The degree of risk posed by a given hazard can be measured in terms of exposure or potential mishap and death.

The pilot flying at 120 knots is familiar with the formulas discussed before or is aware that slower speeds result in a smaller turning radius. The pilot flying at 140 knots does not slow down as he thinks that a 30° bank is satisfactory.

## Perform

In both cases, the pilots perform the turns. The pilot performing a turn at 120 knots exits the canyon safely; while the pilot flying at 140 knots hits the canyon wall, killing all onboard. Another area, although not a canyon, is flying around buildings. Just a few years ago, a pilot collided with a building during a turn. Had he slowed down, he would be alive today.

The 3P model is intended to be a constant loop within which the pilot measures his or her actions through perception of the current, dynamically changing situation. Failure to do so results in error, an accident, and possible death. The pilot flying at 140 knots failed in this endeavor and paid the ultimate price. Therefore, the 3P process must be a continuous loop providing anomalies or reassurance that what is going on is what was predicted or unexpected.

## Chapter Summary

The study of ADM, its history, and models for decision-making while in flight is only a precursor to its practical application. Regurgitating the meaning of the concepts allows a pilot to pass a checkride and written examination, but understanding is what saves lives and improves flight skills. Therefore, one can say that understanding these concepts is superior to being able to state them in a precise order or with absolute accuracy.



